

Beta-Delayed Charged-Particle Emission From ^{20}Mg

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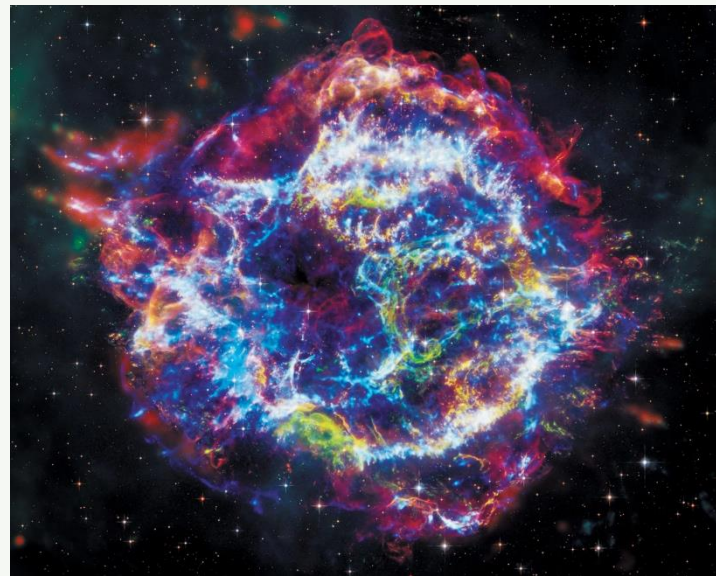
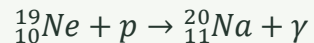
Nuclear Astrophysics

Explosive Nucleosynthesis

- The process of synthesizing elements in explosive environments
 - Supernovae
 - Type-I X-Ray bursts
 - Neutron star mergers
 - And more!

Hot-CNO Cycle

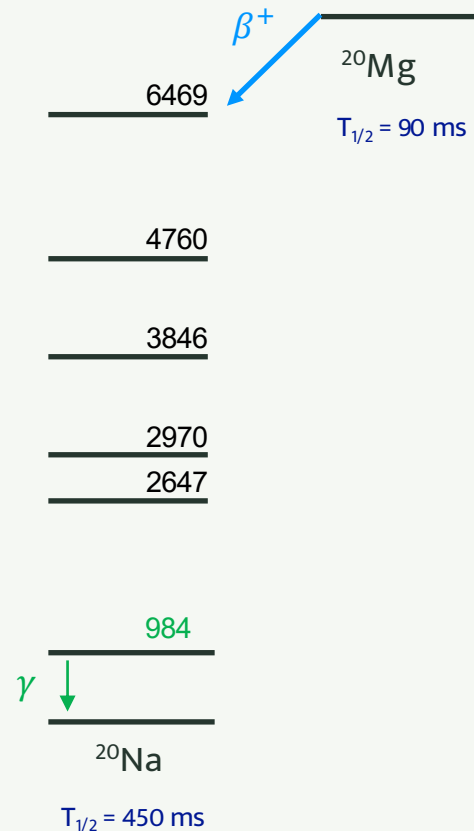
- High temperature H fusion process occurring within stars core
- One of the most important reactions is the $^{15}\text{O}(\alpha,\gamma)^{19}\text{Ne}$, which is the main breakout pathway towards explosive burning



Nuclear Beta Decay

Exotic Nuclei

- Many of the isotopes produced in explosive astrophysical events are short-lived radioactive nuclei
- These isotopes will most likely beta decay over time and result in gamma ray emission



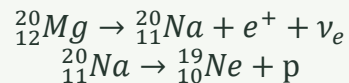
Nuclear Beta Decay

Exotic Nuclei

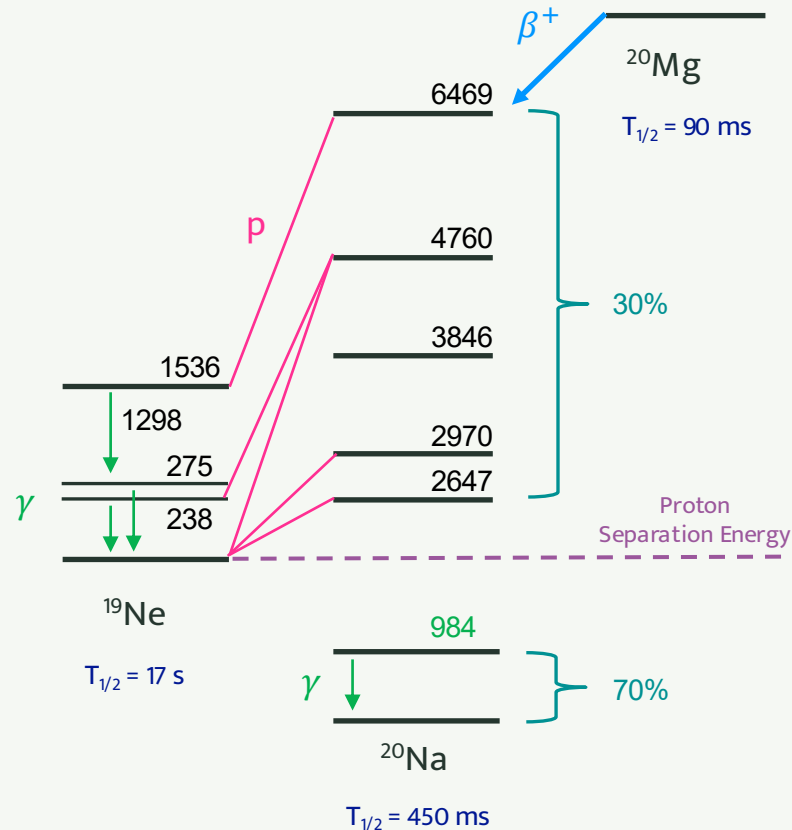
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Beta Delayed Proton Decay (βp)

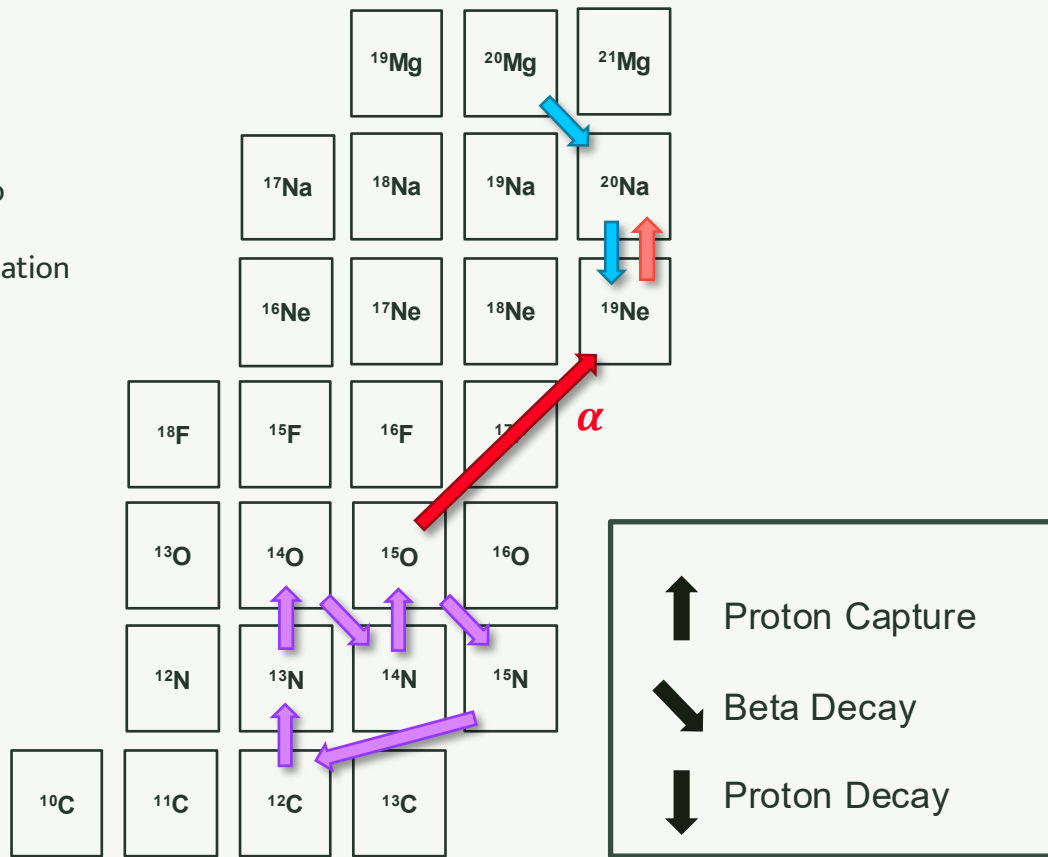
- Nucleus first undergoes a beta decay to states above the proton separation energy before emitting a proton



- Proton decay is the inverse process to a proton capture



- Break-out reaction $^{15}\text{O}(\alpha,\gamma)^{19}\text{Ne}$ challenging to measure directly
- Inverse reaction gives complementary information



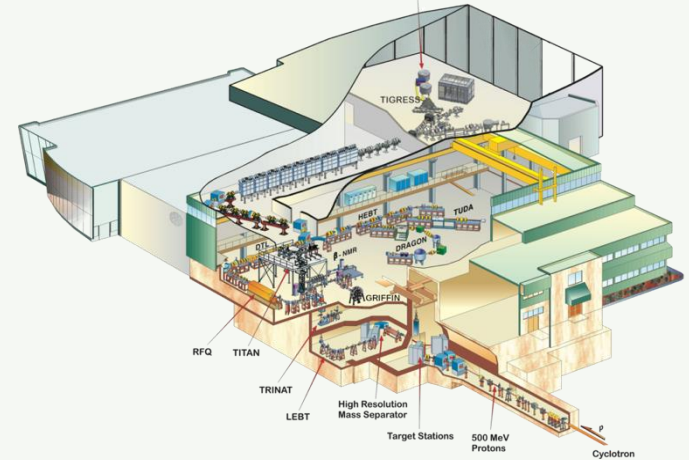
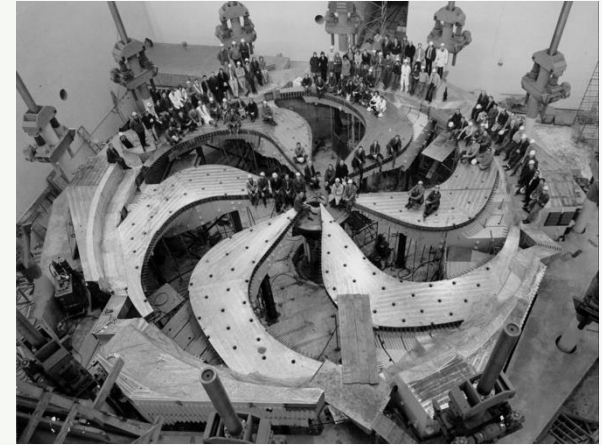
TRIUMF's ISAC Facility

TRIUMF

- Tri-University Meson Facility
- Located in Vancouver, BC
- The world's largest cyclotron
 - 18 meters in diameter
- Produces a 520 MeV proton beam at 100 μ A

ISAC

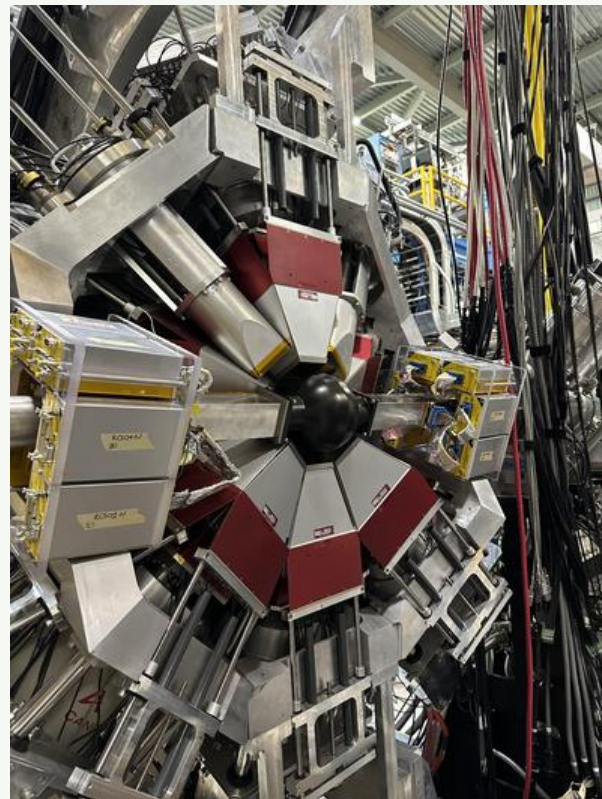
- Isotope Separator and Accelerator
- Low-energy radioactive beams
- Hosts several experimental facilities that focus on studies of nuclear structure and astrophysics



TRIUMF's ISAC Facility

GRIFFIN Detector

- Gamma-Ray Infrastructure for Fundamental Investigations of Nuclei
- The world's most powerful γ -ray spectrometer that is dedicated to nuclear decay studies
- 16 Clover detectors containing 4 High-Purity Germanium (HPGe) crystals



Regina Cube for Multiple Particles

Functionality

- Auxiliary detector for GRIFFIN
- Detects charged particles
 - Alpha particles
 - Beta delayed charged particles
 - Multiple particles ($\beta\alpha p$, $\beta 2p$, etc.)

Design

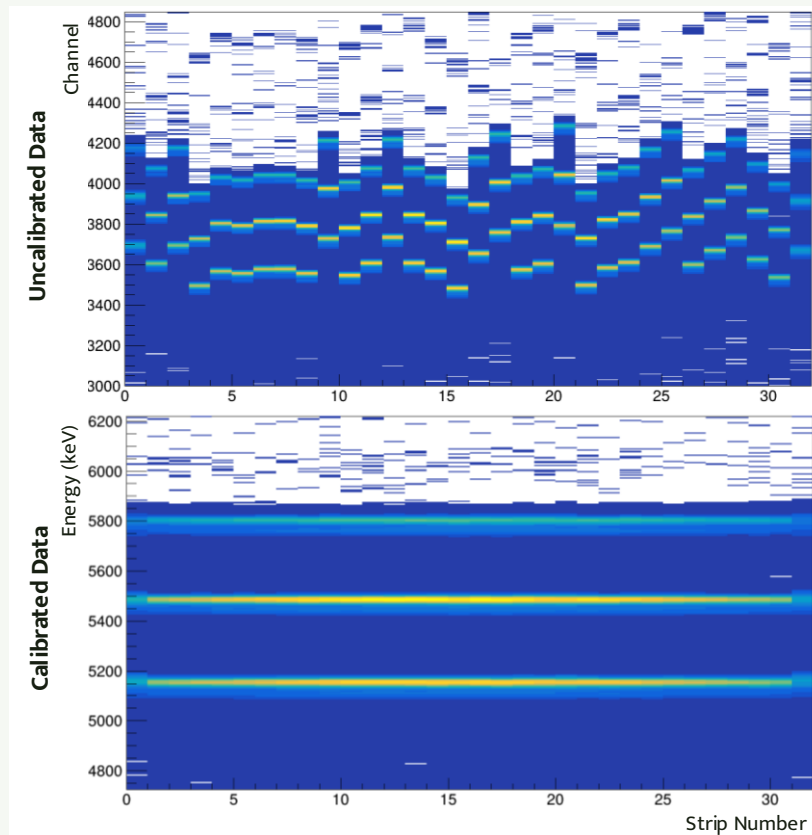
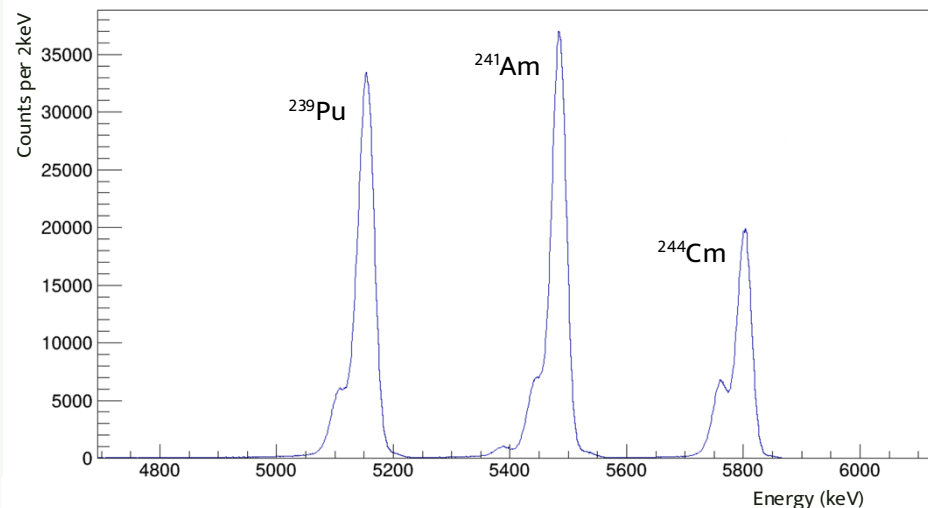
- 6 DSSD detectors
 - 64 x 64 mm²
 - 1 mm thick
 - 32 strips per side, 64 segments in each detector
- Stops up to 12 MeV protons
- ~77% efficiency for proton detection



Energy Calibrations

RCMP

- Triple alpha (^{239}Pu , ^{241}Am , ^{244}Cm)
- Resolution = 30 keV (FWHM) at 5.1 MeV



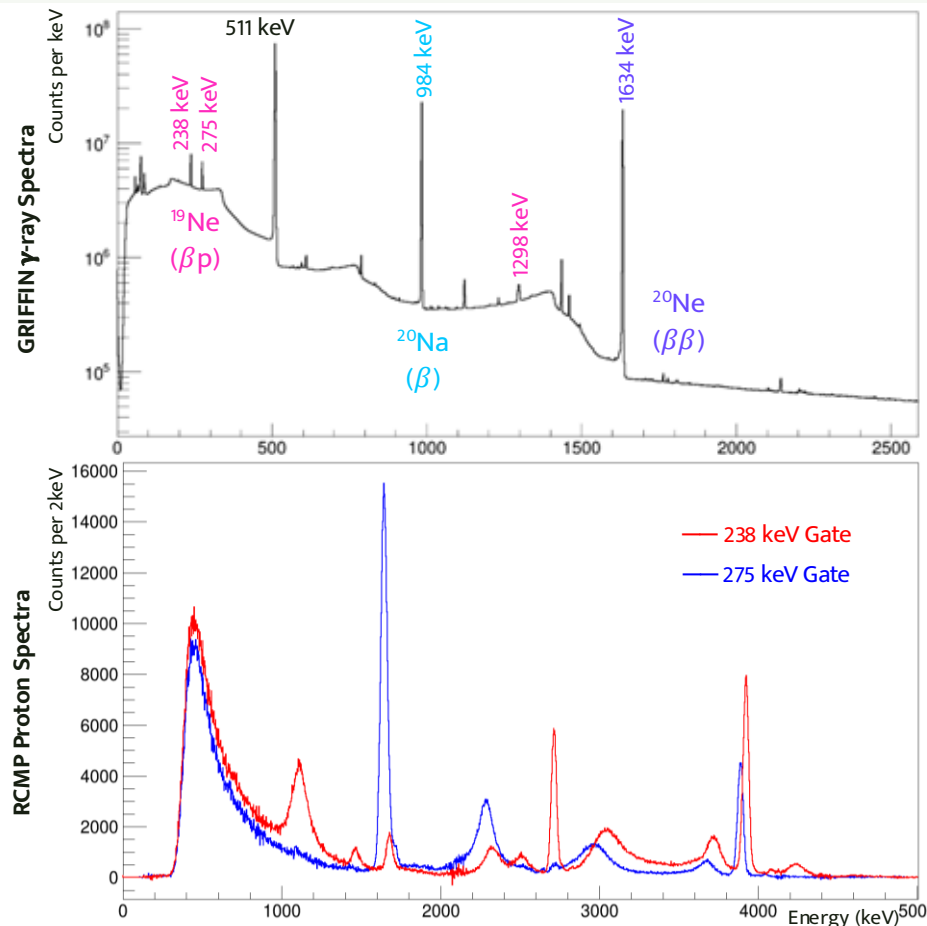
Investigating ^{20}Mg

Experiment

- Experiment S2232 at TRIUMF from July 11th – 14th, 2024
- ^{20}Mg beam at world-leading intensities $\sim 10^4$ ions/s

Data Collected

- Observed γ -rays in $^{19}\text{Ne}(\beta p)$, $^{20}\text{Na}(\beta)$, and $^{20}\text{Ne}(\beta\beta)$
- Gated on the 238 and 275 keV peaks to look at the coincidences between GRIFFIN and RCMP



Investigating ^{20}Mg

Experiment

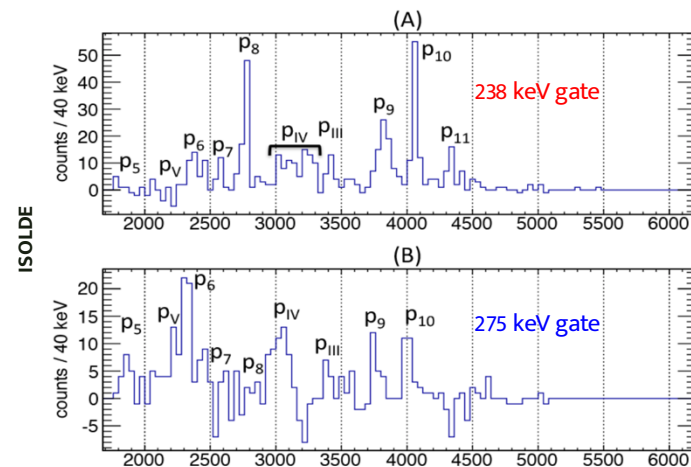
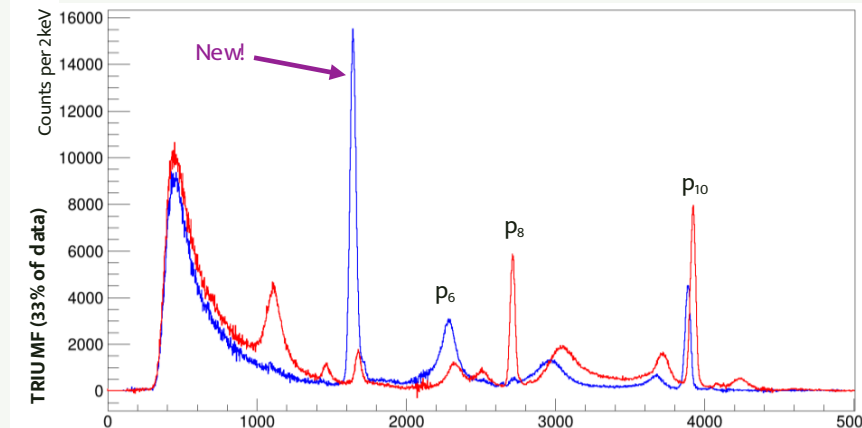
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ISOLDE 2016

- ^{20}Mg decay was previously looked at in a 2016 experiment
- Comparison here shows only 33% of total data
- Peak at 1600 keV outside the range of the ISOLDE spectra



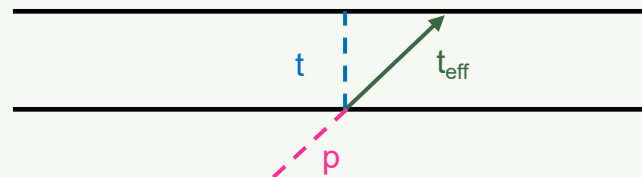
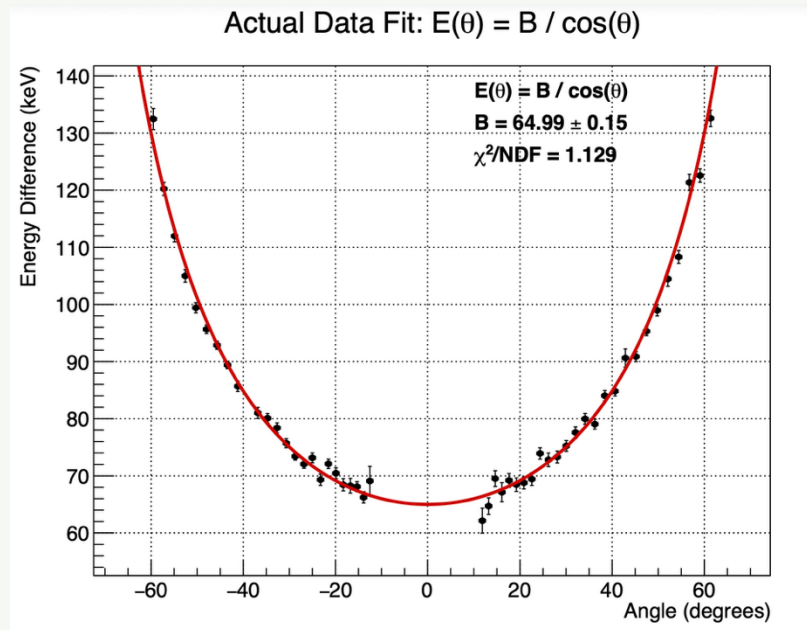
Current Progress

Mylar Foil Thickness Measurement

- Deduced thickness from energy loss of α source
- Comparison to LISE++ at different thicknesses
- Preliminary result: $0.552 \pm 0.001 \mu\text{m}$

Strip by Strip Angle Calculations

- θ and φ angles for each strips were calculated
- Fold in energy loss into calibration (angular dependent)



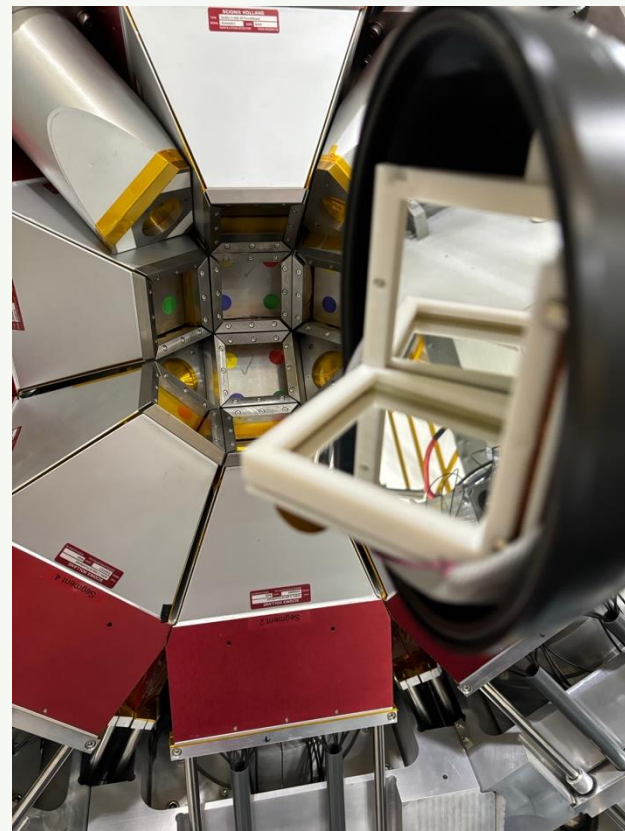
Future Work

My Thesis Work

- Angular dependent energy loss correction
 - Finalizing energy loss procedure
- Efficiency calibrations
 - GRIFFIN (γ -rays)
 - RCMP (β -particles and protons)

RCMP Detector

- Small cosmetic changes to design of frame
- Future experiments planned!
 - Offline source measurement in 2026
 - In beam decay experiments in 2027+
- Go check out the E.Cantacuzene's poster!



Thank You!

S2232 Collaborators

A.A.Avaa¹, G.C.Ball¹, V.Bildstein², A.Calder², M.Cockshutt¹, I.Dillmann¹,
A.B.Garnsworthy¹, E.Geerlof¹, S.Georges¹, C.Griffin¹, A.Grimes¹, G.F.Grinyer³,
G.Hackman¹, J.Liu³, E.McCourt², S.Murillo Morales¹, J.R.Murias¹, S.Plante³,
M.Quinn³, D.Shah³, C.E.Svensson², V.Vedia¹, R.Umashankar¹

Regina Group

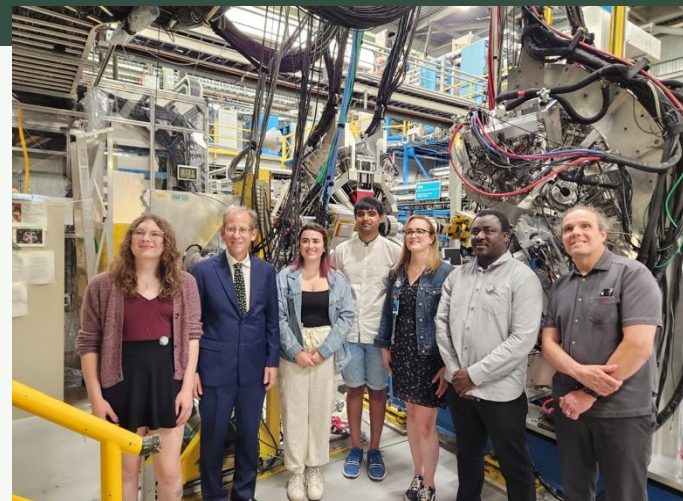
S.Plante, E.Cantacuzène, F.Aljarrah, G.F.Grinyer, J.Liu, M.Quinn,
A.Tsantiri, M.Hladun*, I.Labrie-Boulay*, K.Kapoor*, N.Saei*, S.Sharma*,
J.Suh*, A.Talebitaher*, D.Shah*, Z.Sullivan*

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Sydney Plante, WNPPC, Feb. 12, 2026

Current Progress

Energy Calibrations

RCMP

- Triple alpha (^{239}Pu , ^{244}Cm , ^{241}Am)
- Resolution = 30 keV (FWHM) at 5.1 MeV

GRIFFIN

- Run-by-run in beam calibration
- Resolution = 2.4 keV (FWHM) at 1.0 MeV

